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Estimation of Sediment Yield by Remote Sensing

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Abstract : *The desperate need for food, due to population explosion forces people to over exploit the soil with the result they become degraded and unproductive. The optimum and scientific land use is an important factor governing sediment yield. Soil erosion which includes both physical removal of surface and sub surface soil and deterioration in soil physical properties results in low productivity and siltation of Multipurpose reservoirs. Deforestation, bad mining, road construction, urban development practices coupled with high cattle population result in enormous sediment yield and this finds its way to reservoirs. Data from plot studies, micro and macro watersheds are being used by soil and water resource planners to predict sediment yield. Of late remote sensing has been profitably used to predict erosion and sediment yield. This method takes into account satellite imagery and aerial photos, coupled with ground truth of the watershed on basin. The same is fast, accurate, reliable and is an efficient tool for the planner in India and all over the globe.*

Introduction

The land use information for any given watershed or river basin can be obtained and accurately accessed from satellite imagery and aerial photos. In the modern age of several satellites orbiting the world and constant aerial surveys by air crafts, made these details available on large number. The imagery and aerial photos are available from government and private agency all over the globe. These coupled with ground truths and existing data on soil erosion and sediment loss from plot, micro or macro watershed studies can be profitably used for estimation. The accuracy and reliability of the computed and estimated data depends on the ground truth and the familiarity of the individual to the area to be estimated on. This method was used for Bhavani river basin over an area 6730 KM^2 using false colour composite (FCC) of path 154 and 155 and row 052. The same procedure can be well adopted for bigger rivers. Bhavani river is the major tributary of river Cauvery.

Estimation

Estimation of sheet erosion to predict erosion rate from plot studies commenced several decades back. Zing (10) related steepness and length of slope to soil loss. Smith (4) considered such factors as soil erodibility and land management. Musgrave (3b) introduced rainfall and other parameters and consolidated it. The prediction model known as universal soil loss equation was developed to overcome several deficiencies by Wischmeier et al (7) production of soil erosion using USLE was adopted and the effect of land use change on soil loss has been studied by Chinnamani et al (2,3A) Sixteen test watersheds were used out of which thirteen were on hills of western ghats and three from plains of Tamil Nadu.

The Universal soil loss Equation (USLE) was used as a base. No doubt other equations too can be used.

$$A = R K L S C P$$

Where A is the average annual soil loss in tons per hectare. R is the erosion index or index of erosivity and K is the soil erodibility factor. While S and L are topographic factors, C is the cropping management factor and P is the supporting conservation factor (strip cropping, contouring etc.). For calculating R, energy intensity products (EI value) of storm has to be computed from recording rain gauge chart with the help of energy table Wishmeier et al (6). The rainfall energy in metric system is $Y = 210.3 + 89 \log X$, where Y = is the kinetic energy in metric tonne per hectare contimetre and X is the rainfall intensity in CM/ha Wischeier et al (8). The average R values should be computed seperately for hills plains etc. The average R values computed for hills and plains of Bhawani Basin are 886 and 593 respectively.

The factor K is the measure of the erodibility of a given soil and is evaluated independently of the effects of topography L S, cover and management C and supplementary practice P (1,4,9) when these conditions of independence are met then LSCP becomes equal to one and K equals A/R. From the results of plot studies a graph is plotted between A and R and K is taken as the step of fitted straight line. The values of K factor for hills range from .0001 (forests) to 0.2058 (cultivated and urban). The slope length (L) is determined from equation, $L = (1/22.0)^{0.3}$ where l is the average length of the first order channels in the watershed. The slope S is determined from the following regressive equations.

$$S = (0.043 + 0.30\ G + 0.043\ G^2)/6.613 \text{ for } G \leqslant g$$

$$S = (a/g)^{1.3} \text{ for } G > 79.$$

Where G is percent slope. The topographic maps released by survey of India were used to work out the combined LS factor. The combined CP factor has been taken from the literature published by ICAR(5). The average (P value for hills and plains were worked out. The land use information was prepared on 1:500,000 for the entire Bhavani Basin using landsat False Colour Composite (FCC) of Path 154 to 155 and row 052. With the data collected the following computation were made using USLE.

i) The soil loss of individual watershed present land use (Fig. 1)

ii) The soil loss in individual watershed, assuming scientific management is adopted.

iii) The soil loss of the existing forests are converted into agriculture.

iv) Sediment delivery ratio of a few typical watershed having sediment yield data.

The results of the test watershed is presented in table (1). Soil loss data obtained from plot studies closely correlate with calculated soil loss of certain land uses (Fig. 2). Sediment delivery ratio was also calculated and is given in table (2) and are similar for humid and semi-arid areas of the world (3-A).

The soil loss was classified into 8 classes 0 to 0.01, 0.01 to 1, 1.0 to 5 0, 5.0 to 10.0, 10 to 25, 25 to 50, 50 to 100 and above 100 metric tonnes/ha/year under present and future management strategies which is ideal for future planning by planners.

The estimation was done for Bhavani river of 183 KM length of 6730 square KM with elevation reachingly 300 to 2200 M msl, highest rainfall 6330 mm and rainfall range 350 to 6330 mm and average runoff 2300 million cubic metres with all land uses. This can be followed for estimating any river in India with satellite imagery using remote sensing coupled with ground truth using all the available published and unpublished data available at various

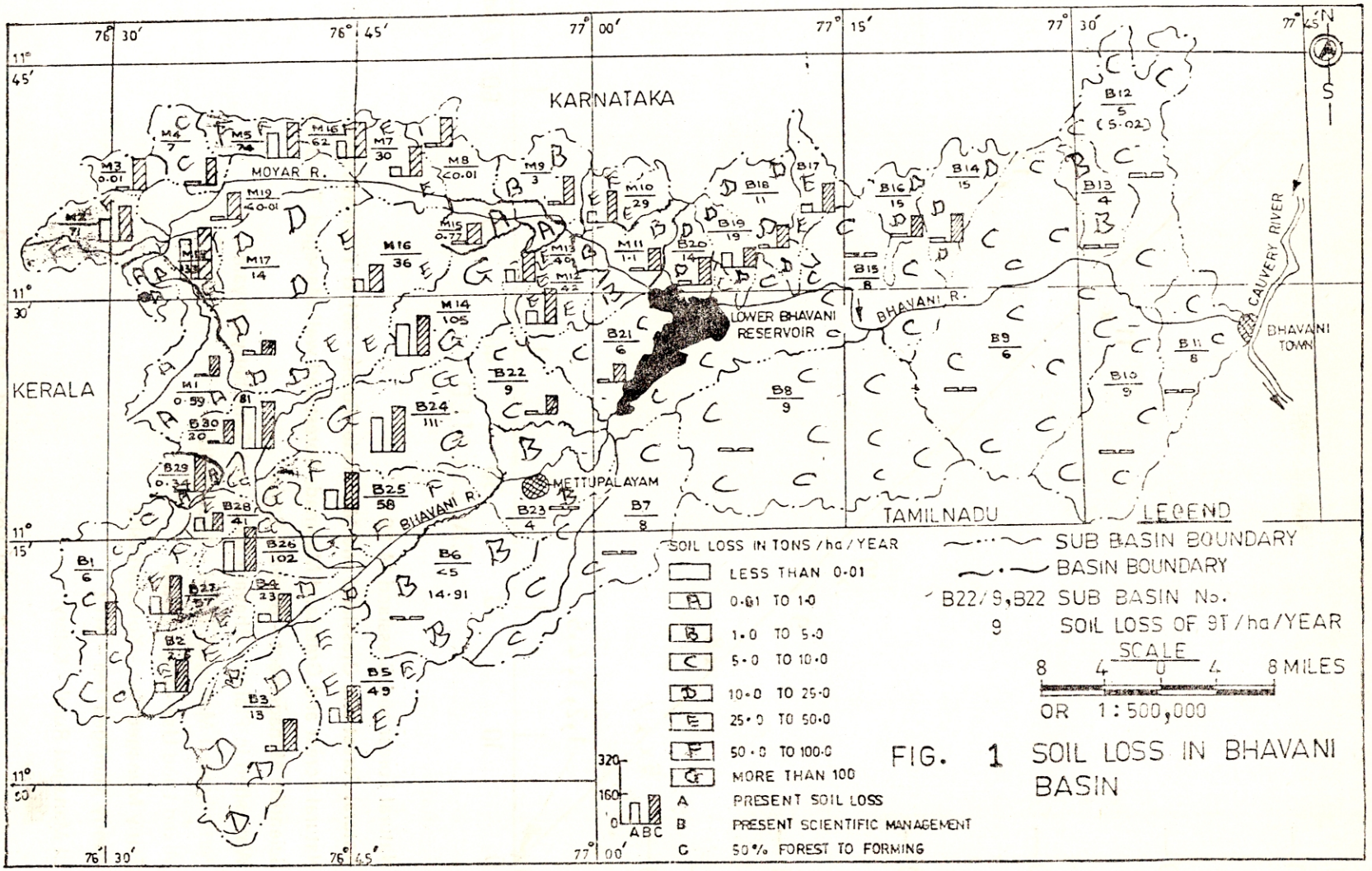
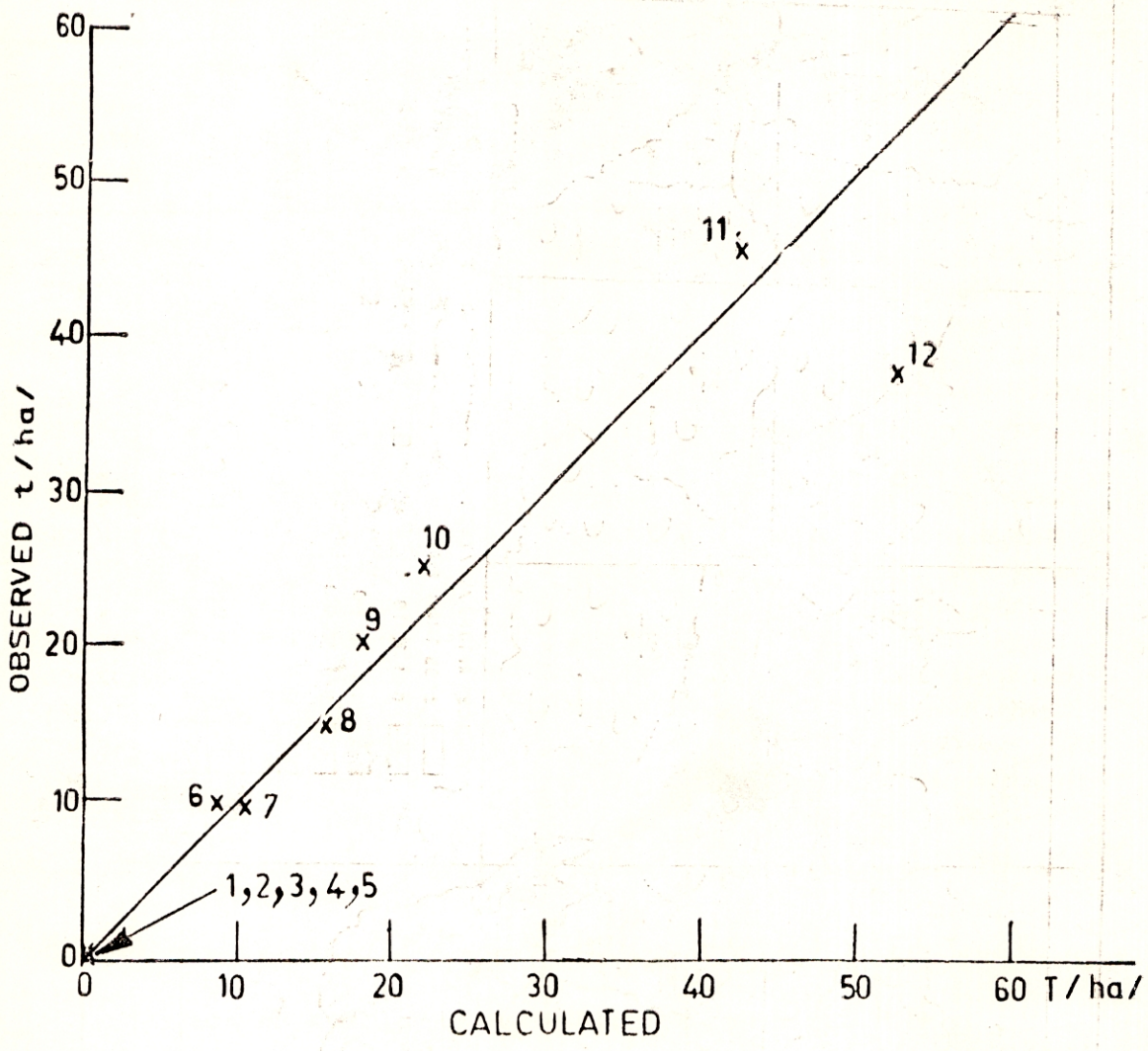


FIG. 1 SOIL LOSS IN BHAVANI BASIN



1. Natural Foresr and Grassland M-19
2,3. Natural Forest and Grassland and Manmade Forest - M1 & Yemmaviruzha
4. Natural Forest and Grassland Manmade Forest and well Managed Tea B-29
5. Scientific Management – Bhavani Basin
6,7. Watershed in Plains – Bhavani Town and Gobichettypalayam
0. Partially well Managed, Rural - Alladahalla
9. Mixed Land Use - Sigur Lower
10. Fairly Managed Tea - Kothagirihalla
11. Poorly Managed Tea – M12
12. Ill Managed Rural - Katery

Fig. 2 Soil Loss Observed and Calculated

Table 1 Soil Loss in the Test Watersheds and the Bhavani Basin

Sl. No.	Name of Watershed	Soil Loss in tonnes/ha/annum		
		At present	Normal Scientific	50 percent forest converted to farming
1.	Coonoor	102.340	1.556	104.919
2.	Upper Moyar	7.491	0.311	24.192
3.	Sigur Lower	12.595	0.226	23.375
4.	Katery	55.556	1.422	56.711
5.	Kukkalathorai halla (upper)	57.243	0.875	61.637
6.	Kukkalathorai halla (lower)	53.194	0.779	60.778
7.	Kedarihalla Lower	8.569	0.125	11.970
8.	Alladahalla	15.807	1.942	19.938
9.	Gundagal halla	68.390	1.000	145.688
10.	East Varahapallam	9.440	0.635	27.910
11.	Yemmavipuzha	0.385	0.376	25.993
12.	Kotagirihalla	22.174	0.851	39.926
13.	Hadothorai halla	51.477	6.669	202.900
14.	Bhavani town	10.281	3.023	10.281
15.	Mettupalayam	27.831	5.827	45.787
16.	Gopichettipalayam	8.658	3.150	9.761
17.	Bhavani as a whole basin	27.417	1.411	62.615

Table 2 Sediment Yield and Delivery Ratio in Bhavani Basin

Sl. No.	Watershed and land use	Sediment yield (t/ha)	Sheet erosion (by USIE) (t/ha)	Channel and gully erosion (t/ha)	Total	DR
1.	Coonoor (Urban)	19.00	102.3410	127.926	230.2600	0.0825
2.	Katery (Rural)	13.95	55.5560	79.550	125.0000	0.1116
3.	Mettupalayam (Low Hills mixed landuse)	3.19	27.7960	34.745	62.5400	0.0510
4.	Nilgiri hills (mixed landuse)	5.85	55.3760	69.220	124 5900	0.0470
5.	Pykara (Forest)	0.00	0.5867	0.7334	1.3201	0 0000
6.	Glenmorgan (Forest)	0.00	0.0001	0.0003	0.0005	0 0000

sources. Such estimation is fast, accurate and reliable.

Conclusion

Estimation of sediment yield by remote sensing using setellite imagery, aerial photos and ground truth were done for Bhavani river basin, a major tributary of river cauvery in India with area of 6730 KM^2. The same procedure can be followed for any of the river basin. This procedure requires a good knowledge of remote sensing and ground truth. The procedure is fast, accurate and reliable. The same can be of great help to planners in planning the river basin with the modern tool of remote sensing.

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